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# Micro-movements of the ankle joint during running acceleration: Effects on ground reaction forces, body kinematics and muscle activity

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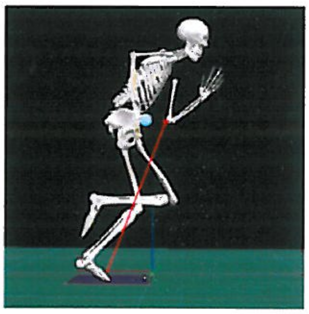
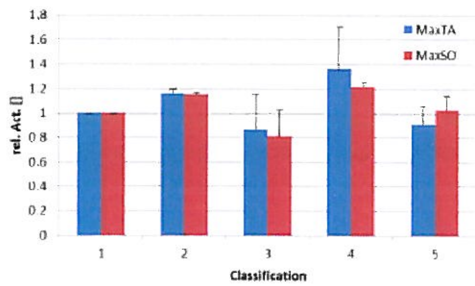
**Introduction:** Ground contact in running is always linked to a minimum amount or foot displacements on uneven surfaces or simply deformation of the ground including small amounts of slipping, i.e., in the early contact phase when horizontal forces are high compared to vertical forces. Various combinations of such micro movements are apparently possible with their implications not yet being investigated.
The purpose of this study was to assess the effects of small anteroposterior displacements, mediolateral inclinations and the combinations thereof on biomechanical and muscular parameters during accelerated running.



**Methods:** Four young and healthy subjects participated in the study (age: 23.4 +/-2 years, height: 178 +/-3 cm, weight: 75.4 +/-3.4 kg).Subjects performed sprinting starts from a standing position with the 4thstep on a movable force plate. The force plate slid backwards at foot contact with 3different amplitudes(4, 6, 8 cm), two velocities without tilting or including an inversion or eversion movement(+/-3 deg)of the foot to simulate a total of nine different contact conditions.
Ground reaction forces (GRF) were collected by the moving force plate (AMTI OR6, USA) at 1000 Hz. Kinematic data werecollected from 45retroreflective markers placed on anatomical landmarks with a 8-camera motion capture system(Qualisys AB, Gothenburg, Sweden) ata sampling rate of 250Hz.
Surface electromyography (EMG) was recorded in a bipolar fashion fromrectus femoris (RF), biceps femoris (BF), Tibialis anterior (TA), Vastus Lateralis (VL), Vastus Intermedius (VI), Vastus Medialis (VM), soleus(SU), and Gastrocnemius (GA)on the perturbed limb(biovision, Germany).
The vertical and horizontal components of the GRF were extracted after compensation for inertia effects of the platform movementto calculate the angle of the GRF vector in the sagittal plane. Further, the center of pressure was calculated and the center of mass position was extracted from the kinematic data using a custom, full-bodyC-motion model (Visual 3D, USA).
EMG amplitudes and time of maximum activity were calculated after standard treatment of EMG data in a time window from 120 ms before touch-down to 250 ms after TD. Amplitudes were scaled to the maximum amplitude during the no-slip condition.

**Results and Discussion:** Only the largest slip amplitudes resulted in a notable change of center of mass trajectory or angle of GRF vector direction. However, all fast slip conditions showed increased muscle activities in the calf with changes being significant for larger slip amplitudes. Inversion in combination to slips further increased calf muscle activity.




**Conclusion:** Subtle slip episodes during the acceleration phase of running did not alter ground contact mechanics substantially. However, at larger amplitudes (>=6 cm), especially in combination with inversion of the foot, lead to significant changes in muscle activity. Future research should focus on the functional implications of micro-movements on injury risk and performance.

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